quite unrelated to the present species. The close, fine pubescence of *H. karstenianum*, *H. spectabile*, and *H. speciosum*, in which the individual hairs are not apparent except under magnification, is very different from the coarse pubescence of *H. amabile*, in which the individual hairs are prominent. All three of these species differ from ours also in their elongate, acuminate (rather than ovate or oblong, obtuse) pinnae. *H. buchtienii* Rosenst. and *H. pulchellum* C. & S. have pubsecence somewhat similar to the present species, but the hairs are less coarse and are sessile or only short-stipitate, in contrast to those of *H. amabile* which are long-stipitate. *H. buchtienii* (from Bolivia) is moreover a much smaller and more delicate plant with non-decurrent pinnae. *H. pulchellum* has a very different range (Mexico) and differs in several particulars from the present species, especially in its smaller size and less divided, petiolate (rather than sessile) pinnae. *H. refrondescens* Sod., of Ecuador, differs conspicuously in its alate rhachises and adnate pinnae; it is known to me from description only. *H. amabile* has terete non-alate rhachises and nearly free pinnae, i.e. not at all surcurrent and only slightly decurrent. *Hymenophyllum chrysothrix* Sturm, a little known species of Venezuela and Brazil, is perhaps most closely related, differing in its finer, less dense pubescence, broadly lanceolate (rather than linear) blade, petiolate (not at all decurrent) pinnae, and subimmersed indusia. The indusium of *H. amabile* is not at all immersed in the leaf tissue.

ZOOLOGY.—*Spawning reactions of three species of oysters.*[1] PAUL S. GALTSOFF, U. S. Bureau of Fisheries.

Since 1927 the author has been engaged in a study of the factors that control the shedding of eggs and sperm of the eastern oyster, *Ostrea virginica.* In 1929 the opportunity presented itself to experiment with the Japanese oyster, *O. gigas*, grown in Puget Sound, and during the summer of 1930 several experiments were carried out with the Australian oyster, *O. cucullata*, and *O. virginica* grown in the waters near Honolulu, T. H. A complete report of these investigations comprising nearly four hundred experiments will be published in the Bulletin of the Bureau of Fisheries.

The technique employed in all the experiments consisted in placing the oyster in a tank of about 20 or 30 liter capacity, in which the water was aerated, stirred and kept at constant temperature. In the majority of the experiments the thermo-regulators were set at 22.5°C. and they maintained this temperature within 0.5°C. The oyster was immobilized with plaster of Paris and one of its valves was attached to a light kymograph lever made of a strip of celluloid. It has been shown

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[1] Published by permission of the U. S. Commissioner of Fisheries. Received January 5, 1932.

in a previous paper[2] that spawning of the female oyster consists of a series of the following reactions: contractions of the mantle, rhythmical contractions of the adductor muscle, and discharge of eggs. Rhythmical contractions of the muscle enable one to obtain a permanent record which can be easily analyzed. The results of a large number of experiments with *O. virginica* carried in 1927–1929 show that no spawning occurs below 20.0°C., whereas the same specimen reacts to the same suspension of sperm as soon as the temperature has been brought above 20.0°. In a few instances it has been noticed that oysters spawned at 27.5° without being stimulated by sperm. Inasmuch as in those cases unfiltered water was used the possibility of its contamination with sperm was not excluded. In the experiments with *O. gigas* it has been found that a ripe female oyster can be induced to spawn by a temperature of 30.0°C. The question naturally arises whether the same results could not be obtained with the other species. During the summer of 1931 experiments were carried out at Woods Hole with ripe oysters which were kept in aquaria at a temperature of about 20.0°C. To avoid possible contamination the water used in the experiments was filtered through a layer of asbestos about three quarters of an inch thick. The results of the experiments, summarized in Table 1, indicate without any doubt that ripe females can be induced to spawn by placing them in water having a temperature from 24.5° to 30.0°C. At 31.0°C. the females usually close their valves and remain closed until the temperature drops to 30° or 29°.

The latent periods of spawning reactions, i.e. the time elapsed from the moment the oyster was exposed to a given temperature until the beginning of spawning, varies from 22 to 257 minutes and apparently is not correlated with the temperature, the quickness of the response probably depending on the conditions of the organism itself. In a series of other experiments which can not be described in a brief article, the females which failed to respond to high temperature (26°–30°C.) readily responded to the addition of sperm. In all the experiments recorded in Table 1 the eggs discharged by the oysters were unfertilized and did not develop. The fact that the females can be stimulated by a temperature of 24.5° or higher suggested the possibility that a similar effect might be obtained by a longer exposure to temperatures between 20.0° and 24.5°C. The results of a long number of experiments, of which only three will be here described, show that this is very doubtful. On July 10 three ripe females were taken from the tank, in which the temperature during the previous week fluctuated between 18.5° and 19.5°C., and placed in an aquarium filled with filtered sea water. The temperature was kept at 22.6°C. but occasionally rose to 23.4°C. The shell movement of each oyster was recorded on the kymograph. The first oyster was kept for 5 hours 22 minutes, the second for 29 hours 53 minutes, and the third one for 73 hours 13 minutes. The water in the tanks in which the second and third oysters were kept was changed twice a day. None of the oysters spawned during that time but each of them spawned after sperm was added to the water the latent periods being 16, 24 and 15 minutes respectively.

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[2] Proc. Nat. Acad. Sci. **16**: 555–559. 1930.

TABLE 1.—SPAWNING REACTIONS OF THE FEMALES OF O. VIRGINICA INDUCED BY TEMPERATURE

Date in 1931	Experiment No.	Temperature °C.		Latent period in minutes	Duration of spawning in minutes
		Before experiment	During experiment		
July 10	325	19.5	24.5	65	43
9	321	19.9	25.0	22	118
7	317	19.9	25.3	250	46
9	322	19.9	26.0	257	38
8	318	19.9	28.0	32	25
8	319	19.9	28.5	55	44
17	340	20.4	30.0	20	?
8	320	19.9	30.0	42	52

It is interesting to note that in both cases of stimulation either by the temperature or by the sperm the reaction is alike and is characterized by a series of rhythmical contractions of the adductor muscle and of the mantle. From that an inference can be made that both factors release some mechanism in the organism of the female which in turn stimulates the adductor muscle and causes the discharge of eggs from the ovary. In this respect the reaction is not specific. It is, however, specific in the sense that sperm of other mollusks (*Mya* spp., *Mytilus* spp.) fail to induce spawning of the oyster. No positive results were obtained also when the sperm of *O. cucullata* was added to the female of *O. virginica* and vice versa. The last experiments are not conclusive, however, because of the failure of the specimens used in the experiments to spawn immediately upon the addition of the sperm of the same species. A few days later the shedding of eggs was successfully stimulated by adding sperm of the same species. Attempts to fertilize eggs of *O. cucullata* by sperm of *O. virginica* and *vice versa* were unsuccessful. There was no formation of the fertilization membrane and no cleavage, whereas in the controls the eggs developed fairly well.

The spawning reaction of the male consists in a discharge of sperm which is carried away by the stream of water produced by the gill epithelium. The reaction is much simpler than it is in the female; it does not involve the adductor muscle and therefore can not be recorded on a kymograph. The males respond to the increase in temperature more readily than the females and often spawn in the tanks when the temperature reaches 24°C. Similar to the spawning of the females the shedding of sperm can be easily provoked by the addition of a few drops of egg suspension or egg water. Unlike the female in which the latent period lasts for several minutes the latent period of the spawning reaction of the male is of brief duration. It lasts only a few seconds. The reaction can be repeated many times until the male is spent. In case of *O. gigas* the males respond to egg suspension even when the water has been cooled to 12.5°C.

In 1930 several experiments with the two species of oysters, *O. virginica* and *O. cucullata,* were performed at Honolulu. The males failed to respond to the addition of sperm of another species but immediately reacted by discharging sperm to the addition of eggs of the same species. These results indicate very clearly the specificity of the response of the male to the presence of eggs. It would be very interesting to extend these experiments to other species of oysters the taxonomic characters of which, as for example those of *O. virginica* and *O. angulata,* are rather indistinct. There is no doubt that physiological differences that might be found would help in determining the validity of the present definitions of various species of the genus *Ostrea.*

Besides being stimulated by the temperature and egg suspension the males of *O. virginica* can be stimulated also by sperm. In that case the latent period of the reaction is approximately of the same duration as it is in the case of the stimulation of the female. A probable explanation is that the active principle of sperm suspension, being insoluble in the sea water, acts upon the organism through the digestive tract.

From a biological point of view stimulation of spawning either by the temperature or by the sperm and egg suspension is of great interest. It provides a mechanism which insures successful propagation of the species. Should the temperature of the water fail to reach the effective point which would induce shedding of eggs by the females, still the spawning of the latter could be provoked by the sperm discharged by the males which are more susceptible to the increase in temperature. In most of the cases observed by the author when several oysters were kept together, the males spawned first and induced the shedding of eggs by the females. The process, once started, spreads by mutual stimulation of the two sexes throughout the whole oyster bed and results in simultaneous spawning of the oyster population.

MALACOLOGY.—*A new land shell of the genus* Rhiostoma *from Siam.*[1]

Paul Bartsch, U. S. National Museum.

Dr. Hugh M. Smith, Fisheries Adviser to His Majesty's Government, Bangkok, Siam, has sent to me for determination a magnificent specimen of *Rhiostoma,* which he collected at Kao Sabap, southeastern Siam, June 28, 1931, at an elevation of 450 meters.

Rhiostomas are ground-dwelling mollusks that frequent leaf mulch, burying themselves beneath such debris, and coming to the surface on moist days. Among a dozen or more known species of *Rhiostoma,* the present one has only one rival for size, namely, *Rhiostoma hainesi* Pfeiffer, from which it is at once distinguished by its lesser number of whorls, *Rhiostoma smithi* having but 5, while *Rhiostoma hainesi* has 7.

Rhiostoma smithi, n. sp.

Fig. 1

The shell is depressed helicoid, excepting the last two-fifths of the last turn which are solute, and which are deflected outward and downward. The under surface is openly umbilicated, all the whorls showing within the umbilicus. The early turns are straw-colored, the later whorls tending to pale olivaceous brown. In the type there are no color markings beyond this except an occasional darker varicial streak. (On the two paratypes, however, we have a subperipheral zone of chestnut brown and fine narrow axial vermiculations of brown. These, however, are not very conspicuous.) The early whorls are sufficiently eroded on the upper surface to make it impossible to differentiate the termination of the nuclear portion in the three specimens before us. The sculpture begins to show on the last half of the second whorl; from there on the shell is covered by a moderately thick periostracum. The sculpture of the shell consists of numerous, slender, threadlike wrinkles which assume almost the strength of slender lamellae on the summit of the whorls near the suture where they have been protected. This in reality represents projecting portions of the periostracum. These incremental threads are closely approximated and are of somewhat varying strength. They give to

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[1] Published by permission of the Secretary of the Smithsonian Institution. Received December 18, 1931.